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# BULLETIN

OF THE

## AMERICAN PHYSICAL SOCIETY

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PROGRAM

OF THE

## CHICAGO MEETING

NOVEMBER 27-28, 1925

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# AMERICAN PHYSICAL SOCIETY

## CHICAGO MEETING NOVEMBER 27-28, 1925

The 135th regular meeting of the American Physical Society will be held in Chicago, Illinois, at the Ryerson Physical Laboratory on Friday and Saturday, November 27 and 28, 1925. The first session will be at 10 o'clock on Friday morning.

On Saturday morning two sessions will be held, in Rooms 32 and 33.

Titles and abstracts of the papers to be presented are given in the following pages. These abstracts have not been corrected by the authors. After correction, they will be published in an early number of the Physical Review. Authors should send corrections to the Editor of the Physical Review at Corning, New York.

*Dinner.* On Friday evening there will be a dinner for members of the Society and their friends at the Quadrangle Club. The price per person will be $2.00. Tickets must be purchased before 2 o'clock Friday afternoon.

**CALENDAR**

Friday morning at 10 o'clock. Room 32: Papers 1-10.
Friday afternoon at 2 o'clock. Room 32: Papers 11-22.
Saturday morning at 10 o'clock. Room 32: Papers 23-34.
Room 33: Papers 35-44.
Saturday afternoon at 2 o'clock. Room 32: Papers 45-54.

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The supplementary papers beginning with No. 55 may be called for at the end of any one of the sessions held in Room 32.

*Kansas City Meeting.* The 136th regular meeting of the American Physical Society will be held in Kansas City, December 28-31, 1925, in affiliation with Section B—Physics—of The American Association for the Advancement of Science. Members intending to present papers at this meeting should have titles and abstracts (**not exceeding 200 words**)

*ready for publication*, in the hands of the Secretary *not later than Tuesday December 1.*

Other meetings for the current seasons are as follows:

137. February 26-27, 1926. Montreal.
138. Pacific Coast Section—Place not yet determined.
139. April 23-24, 1926. Washington.
140. Pacific Coast Section—Place not yet determined.

HAROLD W. WEBB, *Secretary*,
Columbia University, New York City.

# PROGRAM

## FRIDAY MORNING AT 10 O'CLOCK

Room 32

**1. Energy distribution between the modified and the unmodified rays in the Compton effect.** Y. H. Woo, University of Chicago.—Using small tubes of the Compton type and Soller collimators, reliable measurements of the intensity of the scattered x-rays were obtained from five radiators—paraffin, wood, carbon, aluminium and sulfur. In the case of each of the first four scatterers the Mo Kα rays were scattered at 60°, 75°, 90°, 105°, 120°, 135°, 150° and 165° with the exception that for aluminium no reliable result was obtained at 165°. The scattering with sulfur was observed only at 75°, 90° and 105°. The results show that the energy ratio of the modified to the unmodified line for a given radiator increases with increasing scattering angle, as predicted by Jauncey's theory (Phys. Rev. **25,** 314 and 723); but a comparison of the numerical values of the intensity ratio given by Jauncey for carbon and sulfur at 90° with the present results indicates that the theory overestimates this ratio. Experiments were also performed by keeping a lithium radiator in a lead cell filled with hydrogen. As far as they go, the results indicate that in the secondary x-rays scattered from metallic lithium the unmodified line in the Compton effect disappears.

**2. Separation of the modified and unmodified scattering coefficients of x-rays.** O. K. DeFoe and G. E. M. Jauncey, Washington University, St. Louis.—The methods of a previous paper (Proc. Nat. Acad. Sci., **11,** 517) for measuring the ratio of $S_2$, the modified scattering coefficient at a given scattering angle $\phi$, to $S_1$, the unmodified scattering coefficient, have been improved. Instead of measuring the scattered intensities entering an ionization chamber set at $\phi$ before and after the transfer of a certain thickness of aluminum from a position $P$ in the primary beam to a position $Q$ in the scattered beam, we now keep the scattered intensity the same after the transfer as before by allowing more primary rays to fall upon the scattering block. This is done by means of a slit whose opening can be varied. A formula for $S_2/S_1$ is given in terms of the slit openings before and after the transfer of a known thickness of aluminum from $P$ to $Q$ and of the change of absorption coefficient of the modified rays in aluminum on scattering. A null method has been devised, in which two ionization chambers set at the same angle $\phi$ at opposite voltages are connected to the same electrometer. Aluminum is transferred from $P$ to $Q$ for one chamber but not for the other.

**3. A precision measurement of the change of wave-length of scattered x-rays.** H. M. Sharp, University of Chicago.—According to the quantum theory, the change of wave-length of scattered radiation is $\delta\lambda = h/mc\,(1-\cos\phi)$ where $h$ is Planck's radiation constant, $m$ is the mass of the electron, $c$ the velocity of light and $\phi$ the angle of scattering. A test has been made when $\phi$ was 169°, using molybdenum radiation and paraffin as the scattering material. The scattered beam passed to a calcite crystal and slit attached to the x-ray tube and thence to the photographic plate. The observed value of $\delta\lambda$ is $(.04825 \pm .00017)$ A and the calculated value $(.04798 \pm .00009)$A. Using the data of the experiment a value of the *mass of an electron* independent of $e/m$ has been determined. This value is $(8.99 \pm .034) \times 10^{-28}$ g.

**4. Theory of the intensity of scattered x-rays.** G. E. M. JAUNCEY, Washington University, St. Louis.—The theory of previous papers (Phys. Rev. **25,** 314 and 723) predicts a value for the ratio of $s_2$, the energy of the modified x-rays scattered at an angle $\phi$, to $s_1$, the energy of the unmodified x-rays. The theoretical value of $s_2/s_1$, however, is based on the assumption that the probability that an electron will scatter in a direction $\phi$ when it is in an orbital position $M$ to scatter modified rays, is the same as that when it is in an orbital position $U$ to scatter unmodified rays. This assumption is incorrect and, instead of giving $s_2/s_1$, the theory gives $p(\phi)$, the fraction of electrons which at any instant are in the $M$ position, and $\{1-p(\phi)\}$ the fraction in the $U$ position. The angular distribution of the intensity of the modified rays is then given by multiplying the right side of Eq. (27) of Compton's paper or of Eq. (21) of Jauncey's paper (Phys. Rev. **21,** 483 and **22,** 233) by $p(\phi)$. However, due to the invalidity of the above assumption, the angular distribution of the intensity of the unmodified rays is not given by multiplying the right sides of the above equations by $\{1-p(\phi).\}$

**5. Diffraction of x-rays by a ruled metallic grating.** R. L. DOAN and A. H. COMPTON, University of Chicago.—X-ray spectra may be obtained by ordinary optical methods if a grating of large constant is used, with sufficiently small glancing angles of incidence. It is necessary to work within the angle of total reflection, in which case the reflected beam is relatively quite intense. The expression for the wave-length is $n\lambda = \frac{1}{2}d(\alpha^2+2\alpha\theta)$ where $\theta$ and $\alpha$ are respectively the angles of incidence and diffraction. X-rays from a molybdenum target, made homogeneous by reflection from a calcite crystal, were allowed to fall upon a grating at a glancing angle of less than 10 minutes of arc. In the best photographs three orders of spectra were obtained. Measurements of wave-length on the $K\alpha_1$ line gave: $\lambda = (0.707 \pm .001)$A. Experiments carried out with a copper tube were hindered by lack of intensity but such calculations as could be made were satisfactory. More precise measurements on the $K\alpha_1$ radiation from these two elements are now in progress.

**6. The K series emission spectra for elements from atomic number 50 (Sn) to atomic number 83 (Bi).** J. M. CORK and B. R. STEPHENSON, University of Michigan.—Using a spectrograph similar to that previously described except having a greater distance (75.593 cm) between slit and photographic plate, measurements were made upon the K emission spectra of all elements from Sn 50 to Bi 83 inclusive except 54(Xe), 61, 67 (Ho), 75, and 80(Hg). The wave-length values of the $\alpha'$, $\alpha$, $\beta$ and $\gamma$ lines are given in every case except for the $\gamma$ line of Bi 83. In addition the frequency numbers $\nu/R$ and $(\nu/R)^{1/2}$ are given. Variations with atomic number in the value of the regular doublet wave-length difference $d\lambda$ for the $\alpha'$ and $\alpha$ lines, are shown, together with irregularities in some of the outer energy levels of elements in the rare earth group.

**7. Lattice parameters and densities of Cu, Ag and W.** WHEELER P. DAVEY and T. A. WILSON, General Electric Co.—If diffraction patterns of two strain-free crystals are taken on the same film, the crystals have the same equivalent center of diffraction if they are both diluted so as to have the same efficiency of diffraction. A review of diffraction patterns of Cu previously reported showed that this requirement had not been sufficiently met. New patterns have been taken (a) with the calibrating substance (NaCl) mixed with the Cu, and (b) with diluted Cu at one end of the specimen tube and NaCl at the other end. Both methods give 3.605A for the side of the unit cube. This gives a density of 8.95. A single crystal of Cu 3 inches long and 1 inch in diameter gave a density 8.953 by ordinary methods. This changes Patterson's values for Cr and Ti by 0.3 percent. Density measurements by ordinary methods on a large single crystal of Ag gave a density 10.481, agreeing with the previously reported value 10.49 by x-ray methods. New x-ray experiments on W using both methods of calibration confirm the previous result, side of unit-cube = 3.155A; density = 19.32. This value for W is consistent with the new value for Cu.

**8. Theory of the continuous x-ray spectrum.** M. SANDOVAL VALLARTA, Massachusetts Institute of Technology.—A theory is presented, based on the following principles: (1) The continuous x-ray spectrum is due solely to stoppage of electrons on the anticathode; (2) emission takes place as light-quanta satisfying Bohr's frequency relation; (3) conservation of energy and of momentum hold for a system made up of impinging electron, anticathode atom and emitted light-quantum; (4) the impinging electron may or may not lose all its kinetic energy (the loss of energy is at random for different electrons); (5) the relation $m=m_0(1-\beta^2)^{-\frac{1}{2}}$ holds for both electrons and atoms; and (6) mass is equal to $h\nu/c^2$. Differences in electron velocities before impact are neglected, also possible changes in the potential energy of atoms. As may be seen, the continuous and the characteristic spectra are supposed to have a different mechanism of emission. One consequence that can be tested experimentally is that the sharp limit depends not only on the tube voltage but also on the direction of observation and on the anticathode material. This has already been pointed out by Bronstein. The effect is measurable only for voltages less than 1 kv and elements lighter than aluminum. Curves are given showing variation of expected effect for different voltages and different materials.

**9. Energy distribution in the continuous x-ray spectrum.** C. N. WALL, University of Illinois, (introduced by Jakob Kunz).—H. A. Kramers has given a theory which accounts for the main features of the energy distribution in the continuous x-ray spectrum as observed by H. Kuhlenkampff and others. The theory is based upon energy radiation processes which occur in a collision between a free electron and a positive nucleus, and upon ideas underlying Bohr's correspondence principle. In this paper the theory is simplified by considerations of both energy and angular momentum radiation processes which occur during a collision. The result obtained is essentially the same as that obtained by Kramers.

**10. Diffraction of x-rays in liquids.** G. W. STEWART, ROGER M. MORROW and E. W. SKINNER, University of Iowa.—Using the K$\alpha$ radiation from a molybdenum target, the diffraction of x-rays was determined by an ionization chamber placed at varying scattering angles $\theta$. The following are the experimental results: *By Morrow*: (a) Solid and liquid camphor at 21°C and 205°C respectively show the same location of intensity peaks, allowance being made for expansion. (b) Naphthalene, $\alpha$-naphthol and $\beta$-naphthol, as liquids, each give a single broad peak which is roughly a mean of the peaks occurring with the solid state. These single broad peaks occur at temperatures close to the freezing point, also crystalline peaks persist to the melting point. *By Skinner*: (a) In each of the five normal saturated alcohols, methyl, propyl, hexyl, octyl and decyl, a single broad peak is accompanied by a smaller one indicating a larger "grating" spacing. The intensity curves are similar but shifted to smaller values of $\theta$ with the heavier molecule.—The above experiments are favorable to the interpretation of the phenomena as having an interatomic cause, probably the existence of crystal fragments giving low resolving power. All known data are favorable and none contradictory to this assumption of crystal fragments.

## FRIDAY AFTERNOON AT 2 O'CLOCK

Room 32

**11. On some solutions of Maxwell-Lorentz equations which may correspond to Bohr's quantum postulates.** N. RASHEVSKY, Westinghouse Electric and Manufacturing Company, East Pittsburgh, (introduced by Dayton Ulrey).—It is pointed out that the two postulates of the quantum theory, (1) the existence of accelerated electron motion without radiation, and (2) the emission of monochromatic radiation by a non-periodical motion of the electron, are incompatible not with the classical field equations

themselves, but only with their solutions in terms of retarded potential. Using accelerating potentials, solutions compatible with (1) have been obtained by G. Nordstrom and Leigh Page. A way of obtaining solutions compatible with (2) has been indicated by Lonzson for a non-euclidian space. In this paper (a) the general mathematical conditions, which a solution must satisfy in order to be compatible with (1), are investigated; also (b) such a solution is actually constructed by adding to the retarded potentials other suitable chosen solutions of the homogeneous equations; and finally (c) by a similar method solutions are constructed, compatible with (2). It is investigated under what conditions the solution (b) can continuously pass into (c) and vice versa.

**12. The role of the Faraday cylinder in the measurement of the velocities of the electrons emerging from small apertures.** ERNEST O. LAWRENCE, National Research Fellow, Yale University.—The experiments of Lehmann and Osgood (Proc. Cam. Phil. Soc., **22**, 731) led to the conclusion that a large fraction of the electrons emerging from small apertures have velocities less than the velocity corresponding to the applied voltage. However, the efficiency of the Faraday cylinder was not experimentally investigated. Present experiments with a Faraday cylinder of variable dimensions have shown that the observed apparent lack of homogeneity of velocities of the electrons is very definitely a function of the cylinder, indicating that a considerable part of the apparent inhomogeneity is merely due to a re-emission of electrons from the cylinder. These experiments show that Faraday cylinders in general are not as efficient absorbers as is usually assumed. This conclusion is further illustrated by the experiments of J. T. Tate (Phys. Rev. **17**, 395, 1921) who found that the most efficient Faraday cylinder he designed had an absorption coefficient of about .95.

**13. Measurement of the series resistance of a condenser at radio frequency.** CHARLES D. CALLIS, Indiana University, (introduced by R. R. Ramsey).—The variable condenser is placed in a radio frequency ($10^6$ cycles) circuit with a coil made of fine wire with approximately the same high frequency and d.c. resistance. The resistance of the circuit is measured by the well known resistance variation method. The resistance is then measured with a second coil exactly like the first replacing it, and again with the two coils placed in series opposition so as to have the same inductance as that of one coil. From these three readings the resistance of the coils and the resistance of the condenser can be determined. It is found when the coils are made of fine wire that the computed resistance of the coils is the same as their d.c. resistance. Since the computed resistance is the d.c. resistance the assumption is made that the resistance of the coils is independent of position and constant, and that the computed resistance of the condenser is the true resistance. A number of sets of coils were made in order to obtain the condenser resistance at various dial readings. These values plotted against the reciprocal of the capacity give approximately a straight line.

**14. The high frequency resistance of condensers in series.** R. R. RAMSEY, Indiana University.—In attempting to get a check on the work of Charles D. Callis (preceding abstract) it was discovered that if two condensers of the same general type were placed in series in a resonant circuit the resistance of the two condensers in series was approximately the same as the resistance of a single condenser when placed in the same resonant circuit. This is found to be a direct consequence of the ordinary law of resistances in series if the resistance of a variable condenser varies inversely with the capacity of the condenser.

**15. Linear amplification of galvanometer deflection by the photo-electric cell.** F. E. NULL, University of Illinois.—Dr. Jakob Kunz suggested a method whereby the deflection of a moving mirror system may be amplified linearly by reflecting a beam of light from the mirror to a triangular slit in front of a photo-electric cell. This method has the advantage that the photo-electric cell has no lag. It may therefore be used to

secure linear amplification of even short period instruments, such as the siphon recorder used in ocean cable signal reception.

**16. Electricity and Newton's third law of motion.** JOHN A. ELDRIDGE, University of Iowa.—Newton assumes action at a distance and asserts that the action and reaction act in opposite directions on the same line. The "magnetic forces" between two neighboring conductors violate this law, having parallel but not coincident lines of action. The contradiction is in part only apparent because "magnetic forces" are not strictly forces. The terminology is unfortunate since it misleads the student. The actual forces between two charged masses moving in a plane are always in this plane. Insofar as they are directed along the *line joining* the centers of charge they accord with Newton but there is usually a component in the *direction of motion* which is not Newtonian. This situation is usually summarized by saying that the electrical field is not derivable from a potential. While not agreeing with Newtonian mechanics, electrical phenomena are of course in good accord with relativity mechanics.

**17. The electrical conductance of the halides of sodium.** T. E. PHIPPS, W. D. LANSING, and T. G. COOKE, University of Illinois, (introduced by Jakob Kunz).—The electrical conductance of the halides of sodium in the solid state was measured over a wide range of temperature. The powdered crystals were compressed under high pressure to semitransparent disks. In the case of NaCl, the conductance of this disk agreed very well with that of a natural crystal. A relation between conductance and temperature was derived theoretically and found to be $\kappa = ce^{-\epsilon/kT}$, where $\kappa$ is the conductance, and $\epsilon$ is the energy of liberation of an ion in the lattice. Then $\epsilon = -kd \log \kappa / d(1/T)$ and $\epsilon$ can be calculated from the slope of the log $\kappa$, $1/T$ curve. Experimentally, each salt showed two distinct slopes, that at higher temperatures being approximately twice that at lower temperatures. A tentative explanation suggested for this behavior is that the positive ion alone conducts at lower temperatures and both ions at higher temperatures. It was found that for each sodium halide the energy of liberation of an ion in the lower temperature range was approximately 39 times the natural quantum of the crystal as derived from specific heat data.

**18. Shot-effect of electrons produced by impact ionization.** ALBERT W. HULL and N. H. WILLIAMS, General Electric Company.—A two-electrode tube with pure tungsten filament was filled with argon to a pressure of .04 mm. The temperature of the filament was adjusted to give .01 m-amp. emission and the plate voltage raised until this emission current was multiplied ten fold by ionization, giving a total current of 0.1 m-amp. The shot-effect was found to be exactly the same as for pure temperature-limited electron emission. This result would be in harmony with the hypothesis that ionization is effected in two steps, namely, absorption of energy from the impinging electron by the atom as a whole and subsequent emission of an electron after a brief, but random, interval. Such a process would account for the observation of Dushman and Found (Phys. Rev. **23,** 734, 1924) that the ionization in different gases is proportional to the total number of electrons in the molecules of the gases. A much larger shot-effect would be expected on the conventional theory of instantaneous emission, which assumes two low velocity electrons leaving the atom together as the result of an ionizing collision. It is possible, however, that some modification of this theory could account for the observed result.

**19. The "reflection" of electrons from the anode of a Coolidge x-ray tube.** W. R. HAM and MARSH W. WHITE, Pennsylvania State College.—Some of the electrons impinging on the anode of an x-ray tube are "reflected" to other portions of the tube. The ratio of the number reflected to the total number was measured quantitatively and found to be surprisingly large. The method employed was to measure the energy input into a water-cooled tube from a d.c. source and the heat received at the anode. The latter was obtained by using a flow calorimeter method. In a previous paper (Phys. Rev. **23, 777,**

1924) the writers described experiments which proved the equivalence between the energy input into an x-ray tube and the heat which is ultimately produced. Consequently the fraction of the electrons which are reflected is the ratio of the difference between the total energy and the heat generated at the target to the total energy input. The data indicate that the percentage of reflected electrons rises from approximately 15 at 3 kv to 27 at 5 kv and then falls off to 5 at 20 kv. These data were taken with a current of 10 m-amp. The experiments are being continued to study the variation of the reflection coefficient with other factors.

**20. Thermionic work function and space charge.** J. SLEPIAN, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—Work function and space charge are separated on the basis that work function is microscopic in nature and space charge macroscopic. The work function then varies with electron space density, becoming zero or negative if the electron space density is sufficiently high. For an electrode in contact with a completely ionized gas at atmospheric pressure, the work function is reduced by about 0.6 volt.

**21. Emission of positive ions from hot tungsten filaments.** R. L. KENWORTHY, University of Iowa, (introduced by John A. Eldridge).—Jenkins has shown that when the filament of a Coolidge tube is made very hot, positive ions are emitted. If heated for some time with reversed potential (which kept the positives from leaving the filament), the available positive ions appeared to accumulate so that when later an attracting field was applied an abnormally large positive emission was observed for several minutes. Using a special two element tube the phenomenon was further studied. In general Jenkins' results were confirmed. It was found that the proportion of the evaporated atoms which carried a positive charge was 1 in 1600.

**22. Thermionic and evaporation characteristics of adsorbed films of caesium on tungsten.** J. A. BECKER, Bell Telephone Laboratories, Inc.—When a tungsten filament in caesium vapor is heated above a critical temperature $T_c$ of 800°K, every atom that strikes evaporates as a positive ion. When the temperature $T$ is lowered to 600° K, the caesium deposits, the electron current increases, comes to a sharp maximum at $t_m$ seconds, decreases and later becomes steady. This shows that a certain number $N_0$ of caesium atoms produce an optimum activity. If the initial $T > T_c$ and the final $T < 600°$, $t_m$ depends only on the positive ion current $i_p$. Hence above $T_c$ the filament is bare if we draw positive ions; and below 600°K every atom that strikes sticks, at least until $N_0$ have stuck. If $i_p$ is changed by varying the bulb temperature, $i_p \times t_m$ remains constant. From the value of this constant, $N_0 = (3.9 \pm .2) \times 10^{14}$ atoms/cm², which indicates that at the optimum the caesium is closely packed and has its atomic rather than its ionic diameter. Varying the initial conditions before lowering $T$ shows that if the plate is negative both atoms and ions evaporate, while if it is positive only atoms evaporate. The atomic rate of evaporation increases with the fraction of the surface covered, whereas the ionic rate decreases.

## SATURDAY MORNING AT 10 O'CLOCK

### Room 32

**23. Coloring of glass in ultra-violet light.** C. L. CROSS, University of Iowa, (introduced by John A. Eldridge).—It is known that glasses containing manganese are tinted when subjected to x-ray or radioactive illumination and that the same phenomenon occurs when the glass is subjected to ultra-violet light. The phenomenon is closely related to phosphorescence. It is found that the effective light has a wave-length only slightly greater than 2900 (the absorption limit of the glass). Consequently the tinting is confined to very near the surface. The tinting is greatly hastened by heating. Two

different colors may be obtained depending on temperature. At room temperature a brown color is produced which with time turns to purple. At 100°C the purple is produced at once. The reverse action (decolorizing) is accelerated by heat or visible light. A possible mechanism is suggested.

**24. Studies on active nitrogen.** RICHARD RUDY, Nela Research Laboratory.—Afterglow was produced in a bulb containing nitrogen at a few mm pressure by passing a momentary discharge through the bulb. The rate of decay of the afterglow increased with increasing nitrogen pressure, so that the total light emitted became smaller and smaller. This effect was of the same order as the extinction of fluorescence in mercury when the density is increased. Argon, up to a few cm pressure, had little influence on the rate of decay. The decay was found to follow a bimolecular law for the first 100 seconds. The temperature coefficient of this reaction, between 20° and 130°, is much smaller than that of ordinary chemical reactions. For a bright afterglow all the bands of the first positive group of nitrogen were observed. In a bulb about 20 cm in diameter, afterglows lasting more than 15 minutes were obtained. The nitrogen molecule retains vibrational energy and therefore reacts quickly with other substances, or causes them to emit light, as if at high temperature. Band spectra excited by active nitrogen (particularly if the vibrational quanta are not too different) show vibrational energy as if at high temperature, whereas the rotational energy indicates low temperature.

**25. Effect of the type of source on the primary standard of wave-length.** GEORGE S. MONK, University of Chicago.—Owing to its use as the primary standard of wave-length, it is of fundamental importance to know under what conditions of production, if any, the wave-length of the red Cd line 6438.4696 A, will vary. Accordingly, several sources have been studied by the use of the Fabry-Perot etalon and auxiliary grating dispersion. In agreement with the determinations of Hamy it is found that the electrodeless tube yields the same value as one with electrodes. The design of the tube and the type of discharge have no observed effect on the wave-length. The cadmium-filled carbon arc in vacuum gives the same value, but owing to greater intrinsic line width, the measurements from this source are attended by a larger error. Also, some interesting differences in intensity have been observed. The strongest visible line in the sharp singlet series, λ5154, is subject to measurements of the highest order of accuracy, but on account of its relative faintness is not desirable as a standard of wave-length.

**26. Greater dispersion in the extreme ultra-violet.** R. J. LANG and STANLEY SMITH, University of Iowa, (introduced by G. W. Stewart).—The construction and operation of an optical *vacuum-grating spectrograph* capable of accommodating a grating of two meters radius of curvature is described. Means are provided for introducing and removing the photographic plate as well as for altering the focus and inclination of the grating while the vacuum is maintained. *Doublet separations for* $C_{II}$. The following doublets in Fowler's series have been resolved. For $(2\pi_{1,2}-3\sigma)$, $\Delta\nu=64$ in the second order of the grating and 60 in the third order. For $(2\pi_{1,2}-3\delta)$, $\Delta\nu=64.5$ in 2nd order. For lines $\lambda=1335$ $\Delta\nu=65$ and lines $\lambda=1036$, $\Delta\nu=62$ showing that since the 1036 line belongs to $C^+$ probably 1335 does also. *Doublet separation for* $Si_{III}$. In this series the doublet $(3\sigma_{1,2}-4\pi)$ has a separation $\Delta\nu=153$.

**27. Stripped oxygen.** I. S. BOWEN and R. A. MILLIKAN, California Institute of Technology.—We have heretofore obtained and published the spectra of the stripped atoms of all the elements contained in the first two rows of the periodic table except oxygen and fluorine. We can now report the successful stripping of the oxygen atom and the location of the doublet corresponding to the first term of its principal series at λλ1031.97, 1037.69. The ionization potential is here 137 volts, a number higher than that possessed by any of the atoms thus far stripped, or indeed of any optical series thus far worked upon. We have also obtained the $pp'$ group of the two electron system $O_V$,

with such resolution as to clearly bring it out as a sextriplet instead of a quintriplet, and to fix the $p_1p_2/p_0p_1$ (Sommerfeld notation, Atombau p. 577) ratio for oxygen at 2.27, a ratio fairly close to the value shown by all two-valence-electron systems except beryllium.

**28. The pp′ groups in atomic spectra.** R. A. SAWYER, University of Michigan.—In order to explain the *pp′* groups in two-valence-electron systems, Wentzel, and Saunders and Russel have suggested that the second electron makes a *ds* transition, while Bowen and Millikan favor a *ps* transition. The present paper suggests as a more general relation that the *pp′* frequency is associated with the difference in frequency between the two lowest singlet levels in the spectrum concerned and with the difference in level between the two lowest doublet levels in the next spectrum (once more ionized atom). This may be a singlet *SP*, singlet *SD*, doublet $\sigma\pi$ or doublet $\sigma\delta$ transition. For certain two-valence-electron system spectra the *pp′* frequency is nearly a mean between the lowest singlet *SP* transition and the lowest doublet $\sigma\pi$ transition of the next system. From this relationship the location of the *pp′* group of ZnI has been predicted and the group identified. For three-valence-electron systems the *pp′* group is near the lowest singlet *SP* transition of the next system. The $\pi X$ doublet of AlI has been identified. Numerical examples are given and the significance of these results discussed.

**29. The law of force and the size of diatomic molecules, as determined from their band spectra.** RAYMOND T. BIRGE, University of California.—Assuming for the law of force of a diatomic molecule, in the vicinity of the equilibrium position, $F=k_1(r-r_0)+k^2$ etc., explicit expressions for the $k$'s have been derived in terms of the constants of the usual *rotational* energy function for a *non-vibrating* molecule, $E_m=Bm^2+Dm^4+Fm^6$ etc., where $m$ is generally a half integer. Values for the $k$'s, from the *vibrational* energy function of a *non-rotating* molecule may be obtained from the work of Born and Hückel. Although the error is much greater when using rotational data, the two independent values of $k_1$ are found to agree on an average to two percent, for the initial and final states of the CN, CuH, $N_2$ and $N_2^+$ molecules. Dieke's explanation of the intensity anomalies of non-polar molecules requires a moment of inertia $I$ only one-quarter as large as the older accepted values, and this in turn makes the value of $k_1$, from rotation only, just four times as large. Hence the above quantitative agreements, based on the older values of $I$, form conclusive evidence in favor of these older values.

**30. The quantum analysis of the band spectrum of AlO (λ5200-λ4650).** W. C. POMEROY and R. T. BIRGE, University of California.—Using a new form of aluminum arc, spectrograms were taken in 1915 by one of us, in the second order of the large concave grating of the University of Wisconsin. These have now been measured and the (0,0), (1,0), and (0,1) bands of the blue and green group analyzed according to the quantum theory. Although the series lines of each band are concealed in the vicinity of the "origin," these points have been definitely located by an extensive and accurate verification of the combination principle. No other choice of origins gives even approximate verification. The necessary theoretical relations between vibrational and rotational energy constants enable the absolute values of the rotational quantum numbers to be established to $\pm 0.02$. They are exact half-integers. The origin of the (0,0) band (λ4842) is at $\nu_{vac}=20{,}635.3$, and the limiting values of the moments of inertia for initial (emission) and final states are $(46.01\pm0.04)\times10^{-40}$ and $(43.38\pm0.04)\times10^{-40}$ respectively. These bands have no Q branch, and the P and R branches consist of doublets of the violet CN type. The three bands measured have no observable perturbations. Additional theoretical relations are now being tested.

**31. The spectrum of beryllium.** R. F. PATON and W. H. SANDERS, University of Illinois.—The comparatively simple structure of the beryllium atom makes its line spectrum a matter of particularly great interest. However, due to its chemical and physical properties the knowledge of its spectrum is very meager. Fortunately the

authors were able to secure from Dr. B. S. Hopkins a sample of beryllium-aluminum alloy formed in the preparation of pure beryllium. Samples of this alloy used as electrodes in a vacuum spark chamber, furnished a satisfactory source. The spectrum was photographed with a quartz spectrograph. Several satisfactory spectrograms have been obtained and the results tabulated from λ5200 to λ2000. The known lines of beryllium are the most intense on the plates. In addition to these there is a considerable number of new lines which have been ascribed to beryllium, since they occur on all the beryllium plates, but correspond to no recorded wave-lengths and are absent from spectrograms of impurities. More complete data now being taken should permit the classification of these new beryllium lines in series.

**32. The absorption spectrum of manganese vapor.** R. V. ZUMSTEIN, National Research Fellow, University of Michigan.—By heating the manganese in a small carbon tube to about 1600°C, absorption was observed at 31 lines. Grotrian had reported absorption at 6 lines. All of the absorptions are from manganese atoms in the normal state ($1^6s$ term) and occur in groups of 1, 2 and 3 lines. Five absorption lines represent $1^6s-{}^6d'$ combinations for which the rule of inner quantum numbers is obeyed but the azimuthal quantum number changes by 2. Four lines are $1^6s-{}^6p$ combinations and twelve are $1^6s-{}^6p$ combinations. Some of the remainder are perhaps $1^6s-{}^4p$ and $1^6s-{}^2p$ combinations.

**33. The Zeeman effect for the spectrum of flourine.** G. HOWARD CARRAGAN, University of Chicago.—An electromagnet suitable for work on the Zeeman effect at high field strengths has been designed and constructed for the purpose of this investigation. Certain improvements in the technique of handling flourine have been instituted and a form of discharge tube has been devised which is suitable for giving the flourine spectrum under high field strengths. The red spectrum has been photographed in the 1st, 2nd and 4th orders of the 10-inch Michelson grating, and the Zeeman patterns of twenty of the brighter lines obtained. The analysis of these patterns with a consideration of the ratios of the intervals between the lines and the distribution of their relative intensities seem to indicate a quartet system. The principal and diffuse series term combinations have been located on this basis. The term combinations of other lines have been proposed and certain unexplained anomalies in the spectrum pointed out. Certain lines observed by Gale and Monk but not given in their published list of wave-lengths are cited.

**34. Transition probabilities and principal quantum numbers.** FRANK C. HOYT, University of Chicago.—In calculating approximate values of probabilities of transition from the amplitudes in a harmonic analysis of the electric moment of the atom, the order of the harmonic "corresponding" to a given transition depends on the quantum numbers of the stationary states involved. Hence it would seem possible to determine these quantum numbers in doubtful cases by comparison of such computed values with those deduced from experiment. However, in the case of a single electron moving in an orbit of the penetrating type as in ordinary series spectra it may be shown from the harmonic analysis obtained elsewhere (Phys. Rev. **25**, 174, 1925) for such an orbit that the dependence of the amplitudes on the order of the harmonic is such that they are in reality functions only of quantities that may be found from the energies in the stationary states (effective quantum numbers) alone, together with the subordinate quantum numbers. The transition probabilities are thus independent of the assignment of principal quantum numbers. This question is of importance in view of recent attempts to draw conclusions as to the principal quantum numbers from experiments on the intensities, absorption, dispersion, or magneto-rotation of spectral lines.

## SATURDAY MORNING AT 10 O'CLOCK

Room 33

**35. Optimum reverberation in auditoriums.** F. R. WATSON, University of Illinois. —One of the necessary considerations in designing or correcting the acoustics of an auditorium is to secure conditions that will insure an optimum time of reverberation. A number of publications have dealt with this question, but from somewhat different standpoints. The writer has attempted to discuss these results on a common basis to show any differences that may exist.

**36. Transmission of sound by masonry partitions.** PAUL E. SABINE, Riverbank Laboratories.—The reduction of the intensity of sound in transmission from room to room by way of partition walls of masonry was measured by the reverberation method. Eighteen tones, covering the pitch range from 128 to 4096/sec. were employed. Tests were made on walls 50 square feet in area, built into a doorway between two rooms entirely separated structurally. Eighteen walls, including the common types of permanent partitions were tested. The structural stiffness of the partitions was also determined by measuring the yielding of the mid-point under a small excess of atmospheric pressure on one side. For a single tone, the results of the tests were not interpretable. The average reduction over the whole tone range, however, proved to be independent of the structural stiffness of the partition and of the particular material employed and to be a function only of the mass per unit area of the partition considered as a whole. For masonry partitions under the test conditions ranging in weight from 10 to 45 pounds per square foot, the reduction of sound intensity in transmission is given very approximately by the equation $I/i = .593$ (Wt. in pounds/Area in sq. ft.).[512]

**37. The action of acoustic wave-filters in solids.** H. F. OLSON, University of Iowa, (introduced by G. W. Stewart).—Quantitative measurements of transmission in solid filters composed of brass cylindrical masses attached to a brass rod conduit, have been made, and those in which the branches are cylindrical masses of like diameters and lengths show the following results. The application of the formula for low-frequency-pass filters in fluids was found possible provided the inertance of the branch is made equal to 0.75 of the volume and the capacitance of the branch $8.5 \times 10^{-13}$ of the volume. The increase in volume of the branch, the increase in distance between the branches, and the appearance of the additional bands are all in accordance with the formulas for low-frequency-pass-filters. The physical action of the filter is very complicated but the above empirical relations indicate that a simplified theory of the action can be secured.

**38. Anomalous action of the Rayleigh disk.** CHARLES H. SKINNER, Ohio Wesleyan University.—The turning moment on a Rayleigh disk when used to compare sound intensities is usually considered as proportional to the intensity and in such a direction as to set the disk more nearly at right angles to the axis of the resonator in which the disk is mounted. For certain short wave-lengths, however, the turning moment is reversed, and the disk tends to take up a position parallel to the axis of the resonator. The longest wave-length for which this occurs is approximately two times the diameter of the disk, the exact value depending on the relative dimensions of the disk and resonator.

**39. J. W. Fisher's experiments and the possibility of magnetization by rotary fields.** S. J. BARNETT, Carnegie Institution of Washington and California Institute of Technology.—In two recent investigations, with negative results, J. W. Fisher has looked for longitudinal magnetization of ferromagnetic cylinders in a cross magnetic field rotating in a plane normal to their axes. The present paper criticizes Fisher's theory, showing that the magnetization calculated by him should be multiplied by a factor approximately

three halves the ratio of the cross magnetization to the saturation magnetization, thus reducing it ver greatly and making the effect, if existent, undetectable under his experimental conditions. Another investigation of this effect, which is closely related to that of magnetization by rotation, now long established, is in progress here. A magnetic field, approximately uniform throughout a certain toroidal region and with intensity normal to the generating circles of the toroid, is produced and rotated by a two-phase current system. The toroid is filled with a ring, circular in cross-section, of fine permalloy wire surrounded with symmetrical coils in circuit with a galvanometer, whose throw is read when the rotation is reversed. This arrangement takes full advantage of permalloy's enormous susceptibility and eliminates distur ances due to fluctuations of the earth's field; and it is hoped that the elimination of other disturbances will make a conclusive investigation of the effect possible.

**40. Torque on revolving cylindrical magnet.** A. L. KIMBALL, JR., General Electric Co.—In a paper recently published in the Physical Review by Zeleny and Page, it was shown that the explanation often given of the cause of electromagnetic rotation of a cylindrical magnet with a side arm dipping into an annular trough is incorrect, that by taking account of the reaction between the flux and current in the side arm a good check between experiment and theory can be obtained. In the present paper it is shown that the experiment can also be explained by regarding the torque as arising from the reaction between the current in the part of the circuit external to the magnet, and the magnetic field, thus avoiding the necessity of thinking of the torque as arising from a reaction between current and field *both* carried by the suspended magnet, as assumed by Zeleny and Page. Both theories lead to the same law of torque.

**41. Temperature coefficient of magnetic permeability of sheet steel.** THOMAS SPOONER, Westinghouse Research Laboratory, East Pittsburgh.—The temperature coefficients of magnetic permeability as a function of maximum induction and maximum magnetizing force are given for commercial sheet steel such as is used in electrical apparatus. The temperature range is from $-20°C$ to $+46°C$. Three grades of material were tested having a silicon content of approximately 0.9, 2.2 and 4 percent, respectively. The average temperature coefficients have a negative sign for all inductions for the high silicon steel but for the low and medium silicon steels the coefficients are positive for the low inductions and negative for the high. The maximum negative temperature coefficients occur at about 10 kilogauss, which is appreciably higher than the inductions corresponding to maximum permeability.

**42. The role of magnetism in valence.** E. H. WILLIAMS, University of Illinois.—The formation of chemical bonds by electric forces is difficult to reconcile with the Bohr atom. It has been suggested that valence may be due to magnetic forces produced by electronic orbits. The *magnetic susceptibility of odd and even molecules* (molecules containing an odd or an even number of electrons) has now been measured. Four substances containing both odd and even molecules have been tested. Two of these substances, compounds of copper and chlorine, changed from paramagnetic for odd molecules to diamagnetic for even molecules and the other two, compounds of manganese and cobalt, while strongly paramagnetic for odd molecules, became less paramagnetic for even molecules. This was especially noticeable in the case of cobalt compounds which decreased more than ten fold. Two oxides of both tin and lead were also examined. Since the atomic numbers of both of these el ments are even, the oxides form even molecules. In all four cases the substances were diamagnetic. While conclusions cannot be drawn from the limited number of substances worked with, it is interesting to note that in all cases substances that are weakly paramagnetic for odd molecules become diamagnetic for even molecules and substances that are strongly paramagnetic for odd molecules become less paramagnetic for even molecules.

**43. The vapor pressure of solid sodium amalgams.** FRANKLIN E. POINDEXTER, Washington University, St. Louis.—A Buckley ionization gauge was used to measure the vapor pressure of eight sodium amalgams ranging in concentration from 1:1 to 15:1 mol ratio of Hg to Na. The vapor pressure of each amalgam was measured at a number of temperatures which were determined by means of a platinum resistance thermometer. The pressures measured varied from approximately $10^{-3}$ mm to $10^{-8}$ mm over a maximum temperature range of from $-56°$ to 90°C. The log $p$ vs $1/T$ graphs for the different amalgams were found to be approximately straight lines. The heats of reaction were calculated by means of the Van't Hoff reaction isochore, the pressures at different temperatures for these calculations being taken from the log $p$ vs $1/T$ graphs. These heats of reaction varied from 15000 cal. in the case of the amalgams rich in Hg to 14,000 cal. for the 2:1 amalgam. This small heat difference over such a wide range of concentrations indicates that most of the heat of reaction between Na and Hg is liberated in the formation of the initial compounds.

**44. Variation of the coefficient of viscosity of air with the relative humidity.** J. C. STEARNS, University of Chicago, (introduced by H. G. Gale).—The coefficient of viscosity of air with various relative humidities was measured by the concentric cylinder method. The presence of water vapor decreased the viscosity at all pressures. At atmospheric pressure the viscosity was reduced one third percent by saturating the air. At a pressure of 14 mm, the viscosity was reduced by 35 percent of its value when moisture was introduced.

## SATURDAY AFTERNOON AT 2 O'CLOCK

Room 32

**45. Investigation of photo-electric valve coated with potassium.** V. M. ALBERS, University of Illinois.—The tube used by Tykociner and Kunz has been studied more thoroughly. In the case of a transparent deposit on the connecting tube, curves are given showing the current through the tube when illuminated, $I_l$, and when dark, $I_d$. The ratio $I_l/I_d$ reached a minimum at 40 and at 300 volts. The difference reached a maximum for a potential difference of 200 volts. The current increased linearly with light intensity at first and then less rapidly, approaching a saturation value. With an opaque film of potassium, illuminated through a window, the current increased in proportion to the voltage to 1000 volts and also in proportion to the light intensity. Evidently the thicker film gave the more efficient valve. Tests with dispersed light showed that with both transparent and opaque films, the current per unit energy decreased rapidly with increasing wave-length, reaching zero at between 520 and 540 $m\mu$. In explanation of these effects it is suggested that photo-electric emission from the film reduces the accumulation of electrons on the wall which tends to stop the current through the tube by electro-static repulsion. However, this does not explain the variation of the effect with wave-length.

**46. An optical and electric study of the striated discharge in alkali vapors.** A. J. MCMASTER, University of Illinois.—A study of the low voltage discharge in potassium vapor using a hot cathode of oxide-coated platinum wire is being made. When a small quantity of hydrogen is admitted to the discharge tube, beautiful striations of more than one color are produced. The distribution of the potential in and between the striations is measured by the exploring electrode according to the space charge method of Langmuir. A striation exhibits a number of well defined layers of different colors which are investigated by the spectroscope.

**47. Mobility of the ions in the corona discharge.** W. M. YOUNG, University of Illinois, (introduced by Jakob Kunz).—The mobilities of the ions generated in the direct current corona discharge have been directly measured. Gas, moving with a uniform

velocity, has been ionized in a cylindrical corona tube and then passed into an ion chamber consisting of a hollow cylinder with electrodes along the axis. The ion current to the last electrode, when plotted as a function of the cylinder potential, exhibited maxima which indicated the formation of groups of ions. A large number of groups were obtained whose mobilities, for oxygen, nitrogen, and carbon dioxide were all less than .716 cm/sec/volt/cm, ranging down to $10^{-5}$ cm/sec/volt/cm. Nearly all mobilities were found less than $10^{-2}$, the ions apparently being generated in about equal numbers, except that now and then a greater number of a certain mobility were formed. If it can be assumed that the charge determines the mobility of the ion, evidence can be found of ions which contain different charges. However, if mass is the determining factor, then ions may be picked out having the same charge but whose mobility varies inversely as the square root of the molecular weight. The fact that the ions all possessed small mobilities seems to indicate that J. Kunz made the correct assumptions when he calculated the average value from the experimental determination of the pressure increase in the d.c. corona.

**48. On the discharge of electricity between equipotential plates.** MASON E. HUFFORD, Indiana University.—A study has been made of the glow discharge of electricity between a perforated cathode and a connected auxiliary electrode. The dependence of the presence of the discharge upon pressure range was determined with aluminum electrode and various gases, air, oxygen-coal-gas, hydrogen-coal-gas, oxygen, hydrogen and helium. Experiments showed that electrons are evolved from the metal surface behind the cathode and these neutralize the canal rays. Experiments were made to show the relation of total voltage on the discharge tube to the current from cathode and auxiliary plate. Potentials at points in the glow region were measured by the probe method. The change of potential of a fixed point in the glow with change of pressure was tested. Study was made of the glow potentials using copper as cathode and again using gold as cathode. Potentials were measured when the walls of the tube were coated with sputtered metal and the discharge consisted of a glow only. Comparison was made of the fall of potential in the glow region and the cathode fall of potential obtained by other experimenters.

**49. The distribution of potential in low voltage arcs.** O. S. DUFFENDACK and W. S. KIMBALL, University of Michigan.—Langmuir's sheath method was employed in measuring the distribution of potential in low-voltage arcs in hydrogen. The space a millimeter away from the filament is at practically the same potential as the anode. Thus there is a large fall of potential very near the cathode and only a small potential gradient over the remaining space. Only two potential states seem possible for a particular tube, a pre-arc state and an arc state. An oscillating arc is one in which there are rapid transitions between these two states. When a sufficient potential difference is applied between filament and anode of a soft detector or gas filled tube, an arc will strike unless the grid is made negative with respect to the filament; then an arc will not strike until the potential difference between the grid and filament is reduced to a characteristic value. After the arc strikes it becomes independent of the grid potential over wide limits. Such tubes have been used for locking circuits at critical instants and for peak voltmeters. After the grid potential reaches the critical value, an arc strikes in a very short time (order of one ten thousandth second) which becomes less with increasing anode potential.

**50. The scattering and absorption of the gamma-rays of radium.** H. M. CAVE and J. A. GRAY, Queen's University.—(1) Gamma-rays filtered through 2 cm of lead have a mass scattering coefficient equal to $0.102\ Z/A$, where $Z$ is the atomic number and $A$ the atomic weight of the material used. $(\mu/\rho)_{Pb}$ is 0.053. (2) Gamma-rays for which $(\mu/\rho)_{Pb}=0.0475$ have been isolated. (3) $(\mu/\rho)_{Hg}$ is $>(\mu/\rho)_{Pb}$. (4) The distribution of the radiation scattered from paraffin wax has been determined. (5) The results indicate that gamma-rays filtered through 2 cm of lead have an effective wave-length in the neighborhood of 0.012A. It must be stated, however, that the variation of scattering

and absorption coefficients with wave-length is not known with sufficient accuracy for an estimation of this wave-length to be made with any degree of certainty.

**51. Geiger counting chambers.** C. W. HEWLETT, General Electric Co.—A study of Geiger counting chambers has been made, with the object of throwing some light on the mechanism by which radioactive rays register themselves in this type of apparatus. Evidence has been obtained suggesting that, in order to be registered, a radioactive ray must pass through a conical region extending from the point to the walls of the chamber. The extent of the base of this conical region may be very small and located on the end closing the chamber, or it may be large, covering the whole end of the chamber and even part of the side walls, depending upon the distance of the point from the end of the chamber. Examples are given of the determination of small amounts of radioactive matter mixed in relatively large amounts of other matter.

**52. The passage of protons and charged hydrogen molecules through gases.** A. J. DEMPSTER, University of Chicago.—Protons and charged hydrogen molecules with a slow velocity, corresponding to a potential difference of 300 to 900 volts, will pass through many molecules without being neutralized, contrary to what would be expected from the results with canal rays and $\alpha$ rays. Thus protons have been observed with their original charge after 9 collisions with hydrogen and 26 collisions with helium atoms, using the kinetic theory value of the molecular diameters. The rays were still observable, though scattered, when the number of collisions was four times as great as that just mentioned. Similar results hold in the case of charged hydrogen molecules. In air and hydrogen the penetration is somewhat less and the scattering greater. The velocities of the rays are small compared with the orbital velocity of the electrons, so that we may think of the rays as causing only an adiabatic distortion of the electronic arrangement while passing through, and producing no permanent alteration in the electronic distribution. There is no tendency for the helium to give up an electron since its ionization potential is 24.5 volts, and the energy of formation of the neutral atom or molecule considerably less.

**53. Collisions of the second kind in activated ozone.** H. D. SMYTH, Princeton University.—Last February a report was made concerning some experiments on collisions of the second kind between electrons and pseudo-excited atoms in iodine. Extension of the ideas on which that work was based suggests that if an electron collides with an activated molecule, the energy of activation or "critical increment" of the molecule may be converted to kinetic energy of the electron by a collision of the second kind, the molecule, of course, being thereby reduced to a normal state. Experiments have been made on ozone decomposing into oxygen. With a simple arrangement of filament, grid, and plate, the current reaching the plate was measured as a function of a retarding field between the plate and grid. A constant small accelerating field was maintained between the filament and grid. If the process suggested above does occur, there should have been some electrons that had greater velocity than that due to the accelerating field alone, and such electrons should have been able to reach the plate after the retarding field was sufficient to cut off the main group. Some evidence of such high speed electrons was obtained.

**54. Critical ionization potentials by positive ion impact in hydrogen.** W. J. HOOPER, University of California.—The experiments of several previous investigators were repeated in substance with apparatus designed to make it possible to distinguish between ionization and certain spurious factors which have made questionable much of the existing evidence relating to ionization by positive ion impact. A great many current-potential measurements and curves were obtained with a variety of electrical arrangements. The data and curves thus obtained present direct evidence (a) that the previously so-called ionization current is due to a secondary electron emission from the

walls of the ionization chamber and not to ionization of the gas, (b) that this secondary electron emission is produced by the impact of the positive ions against these metal walls, (c) that either there is no ionization in hydrogen gas by the impact of positive ions accelerated by potential differences up to 925 volts, or that if this phenomenon exists, its effects are so small at relatively low pressures (.012 mm) that it is completely masked by secondary phenomena which make its detection by the ordinary direct methods problematic, and (d) that it seems possible that at relatively high gas pressures, ionization by positive ions might be an important factor with accelerating potential differences well within this same range of voltages.

## SUPPLEMENTARY PROGRAM

When two or more papers are offered by the same member, one only of these will be assigned a place on the regular program, while the others will be placed in a supplementary program, to be called for if time permits.

Papers received after the program has been printed will be placed in the supplementary program.

The papers in the supplementary program may be called for at any session in Room 32 after the completion of the regular program for the session.

**55. Measurements of high frequency amplification with shielded-grid pliotrons.** ALBERT W. HULL, General Electric Company.—Further tests have been made with the tubes previously described (abstract, Phys. Rev. **23,** 299, 1924). The distinguishing feature of these tubes is that they are made as nearly unidirectional as possible by thorough electrostatic shielding between the control-grid and plate. The shielding is accomplished internally by means of an extra grid between control-grid and plate, maintained at a constant positive potential, and externally by appropriate arrangement of supporting and leading-in wires and the use of grounded conductors. In this way it was found possible to reduce the effective capacity between control-grid and plate to less than .01 e.s.u. The most interesting application of these tubes is to voltage amplification at high frequencies. Amplification measurements were made at 50; 1,000; and 10,000 kilocycles. At 50 kc the voltage amplification per stage was 200. At 1,000 kc each tube amplified 40-fold, and 4 in series gave a total voltage amplification of 2 million. This is shown to be the maximum amplification that can be usefully employed at any frequency, because of the presence of shot-effect. At 10,000 kc each tube amplified 7-fold, and 5 in series gave 10,000. No oscillations or other evidences of feedback were observed at any frequency. The use of *negative plate resistance* was found to be advantageous for cascade amplification with low battery voltage, and for single tube operation.

**56. Low-voltage characteristic in mercury vapor.** RICHARD RUDY, Nela Research Laboratory.—The low-voltage mercury arc studied is produced between a surface of mercury and tungsten ribbons 1 to 2 mm wide and 1 to 3 cm long. As the electron emission is increased, the characteristic is gradually shifted towards lower voltages, and the arc finally becomes an abnormal low-voltage arc. Increasing the temperature of the ribbon lowers the voltage of the arc until strong currents pass at voltages lower than the first excitation potential. No oscillations are observed, since the characteristic is rising. Reverse fields may exist in the ordinary as well as in the abnormal low-voltage arc. These have been investigated by measuring the resistance of the arc by means of superimposed high frequency currents. With moderate heating of the filament the saturation current is well marked and is followed by a linear increase in current with the voltage, as ionization again sets in. The slope of this straight line is nearly proportional to the saturation current. With strong electron emission the ionization masks the saturation current. Currents of over half an ampere are possible with the anode less positive than the positive end of the filament. The effect of argon on this low voltage arc has also been examined.

**57. Transmission of sound by double-wall partitions.** PAUL E. SABINE, Riverbank Laboratories.—The average reduction of intensity of sound in transmission by a single wall of gypsum tile was measured over the frequency range, 128 to 4096/sec. A second wall of the same weight and material was built without any structural connection and with an intervening air space of 2 inches between the two walls. The effects of structurally bridging and of filling this space with different materials were determined by measuring the transmission of sound by these structures. The following ratios of intensities, upon opposite sides of various composite walls of this type were obtained: single wall, 420; double wall bridged with wood, 10,300; double wall, sawdust filled, 8,700; double wall, slag filled, 11,300; double wall, felt filled, 31,000; double wall, completely separated and without filling, 32,000. The conclusion is drawn that the bridging action of a filler of absorbent material more than offsets the reduction of acoustical energy due to absorption by such a material.

**58. The practical importance of relativity.** JOHN A. ELDRIDGE, University of Iowa.—The restricted theory of relativity is usually considered recondite, without *practical* application. It is true that Newtonian mechanics are sufficiently accurate in other engineering applications, but not in the field of magnetism the existence of which is an indication of the breakdown of classical mechanics. In an electrical age it is hardly possible to consider relativity as an impractical refinement upon the Newtonian mechanics.

**59. The disappearance of the unmodified line in the Compton effect.** G. E. M. JAUNCEY, R. A. BOYD and W. W. NIPPER, Washington University.—Jauncey's theory of the unmodified line (Phys. Rev. **25**, 314) requires the disappearance of this line at values of the scattering angle greater than that given by vers $\phi = 242\ \lambda_0^2/\lambda_s$, where $\lambda_0$ is the wave-length of the primary x-rays and $\lambda_s$ is the K critical absorption limit of the scattering substance and both $\lambda_0$ and $\lambda_s$ are given in angstroms. For the scattering of Mo K$\alpha$ or Mo K$\beta$ x-rays by carbon or by any element of higher atomic number, there is no real solution of the above equation and the unmodified lines are always present. However, for scattering by boron the unmodified K$\alpha$ and K$\beta$ lines should disappear at 147° and 117° respectively. We have accordingly scattered Mo x-rays by boron at about 145° to 150° and have examined the scattered spectrum photographically by means of a Sieman-Ross x-ray spectrometer. After a 60 hour exposure the modified K$\alpha$ and K$\beta$ lines show up plainly but the unmodified lines are either absent or are so faint that they escape detection. Further experiments are in progress.

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